Asthma and Air Pollution: Associations Between Asthma Emergency Department Visits, PM 2.5 Levels, and Temperature Inversions in Utah

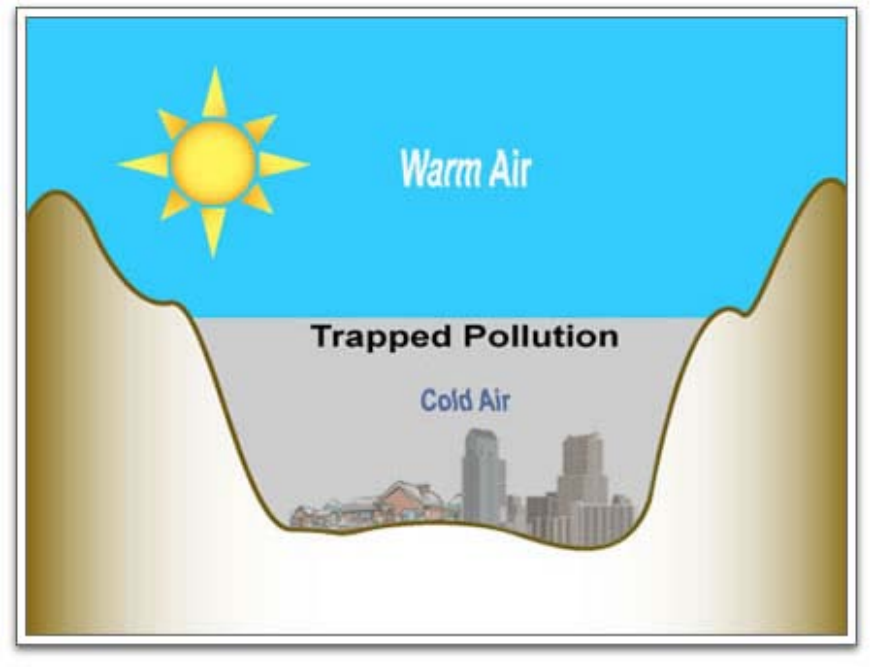
Presented November 16, 2010
Utah Department of Health
Canon Building, Room 125

Inversion Definition

•Occurs during winter months when normal conditions (cool air above, warm air below) are inverted

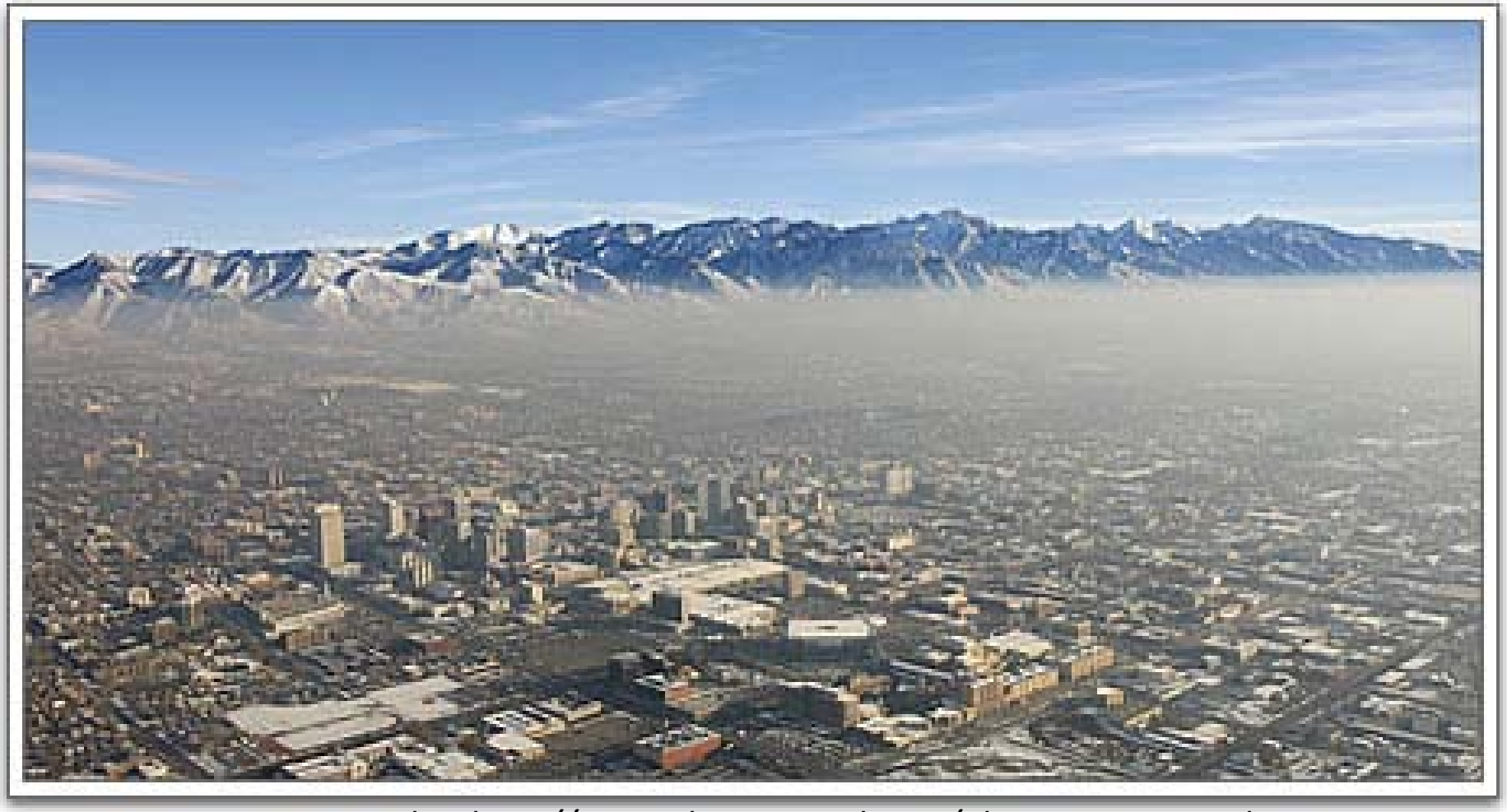
•Pollutants become trapped within cold air near valley floor

•Primary winter pollutant is particulate matter (PM)



Source: Utah Department of Environmental Quality, http://www.cleanair.utah.gov/about_inversions.htm accessed March 2010

Salt Lake Valley During Inversion



Source: Accessed at http://www.cleanair.utah.gov/about_inversions.htm on March 10, 2010. Photo credit: Tom Smart, Deseret Morning News

Analysis Objectives

- Understand changes in PM2.5 levels during temperature inversions and implications for people with asthma
- Assess odds for emergency department (ED) visits for asthma associated with temperature inversions
- Assess odds for ED visits for asthma associated with increases in ambient PM2.5

Partner Collaboration

- Utah Asthma Program
- Utah Department of Environmental Quality
- National Weather Service
- UDOH Environmental Epidemiology Program
- UDOH Environmental Public Health Tracking Network
- UDOH Office of Health Care Statistics

Study Methods and Criteria

Inversion Criteria

- Criteria for identification
  - Based on daily soundings in Salt Lake Valley
  - Morning and afternoon inversion
- Identified inversion days
  - Dec 2006-Feb 2007: 35 days (38.9%)
  - Dec 2007-2008: 10 days (11.1%)

Data Used

- Daily emergency department encounter data[1]
- Air pollutant data (PM2.5, ozone, NO2, SO2, CO, PM10) [2]
  - PM2.5 daily 24-hour average used
  - PM2.5 measured from nearest monitor to residence
- Daily temperature and humidity data[3]
- Identified inversion days (winters 2006-2007 and 2007-2008)[4]

Data Sources:
1. Provided by UDOH Office of Health Care Statistics
2. Accessed from EPA website http://www.epa.gov/airexplorer/ during March 2010
3. Accessed from Utah Mesowest website http://mesowest.utah.edu/index.html during March 2010
4. Provided by National Weather Service in Salt Lake City, UT

Study Design

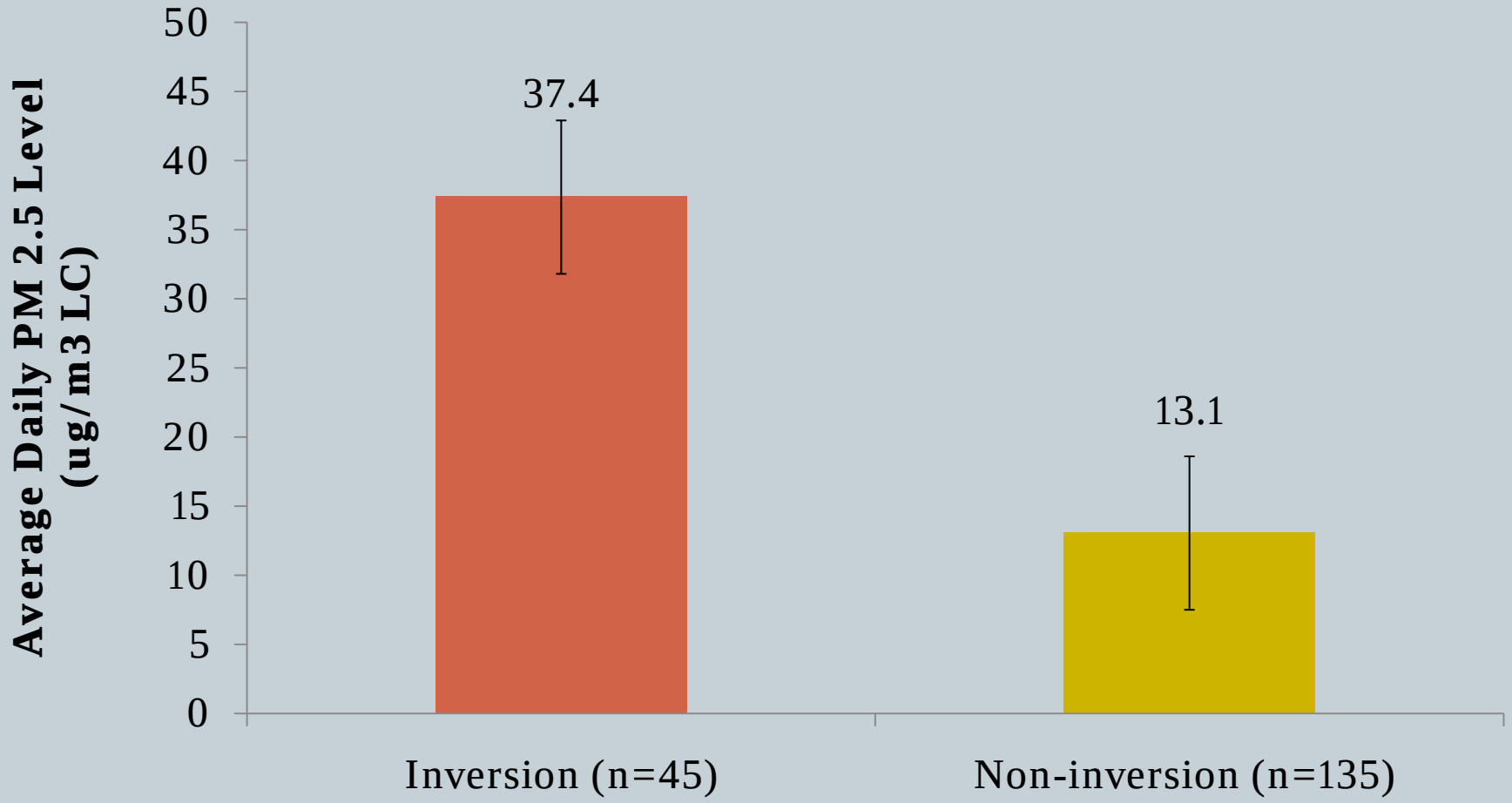
- Area of study
  - Salt Lake County
  - Highest population density
- Time-stratified case-crossover design
  - Cases serve as their own controls
  - Odds based on exposure on case vs. control days
  - Day of week and personal characteristics controlled for in design
  - Seasonal effects minimized

Analysis Methods

- Descriptive statistics
- Conditional logistic regression
  - Outcome of interest: ED visit with primary diagnosis of asthma
  - Exposure variables: inversion, day of inversion, air quality index (AQI), inversion or AQI with<=3 days lag time
  - Covariates adjusted for in final model: NO2, SO2, ozone, temperature

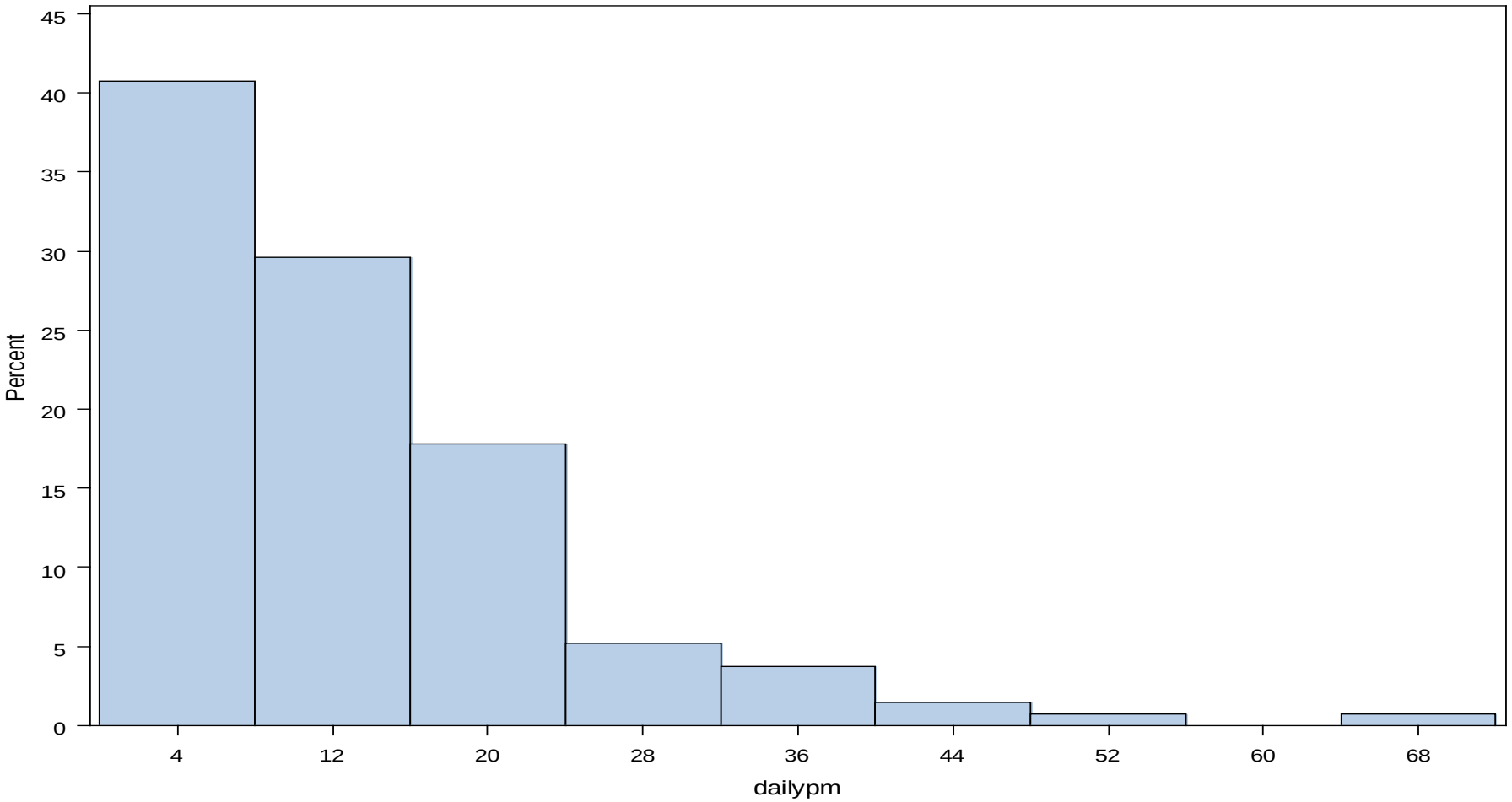
Results

Average PM 2.5 levels for Inversion vs. Non-inversion Days

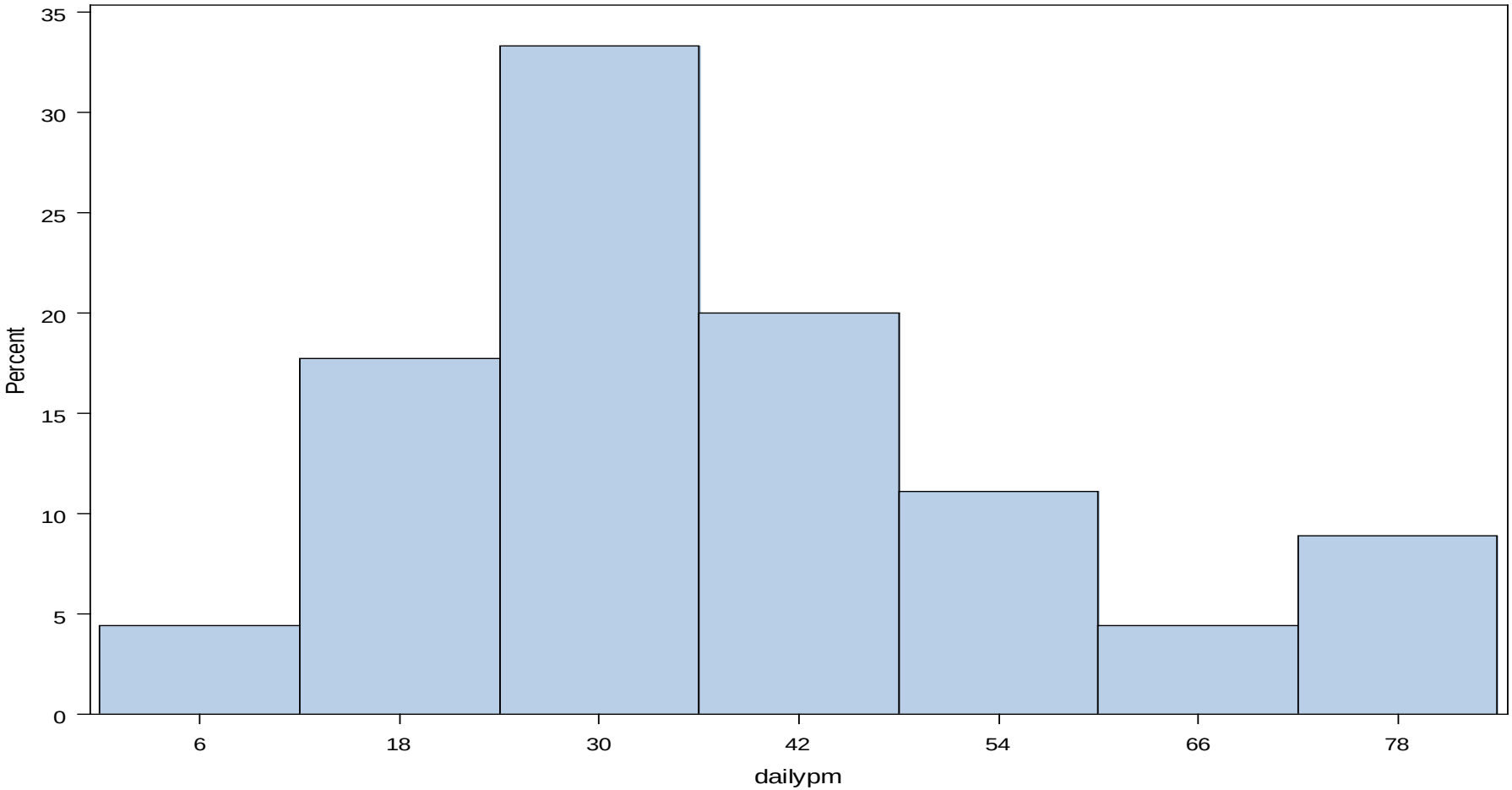


Data Source: http://www.epa.gov/airexplorer/ accessed March 2010.

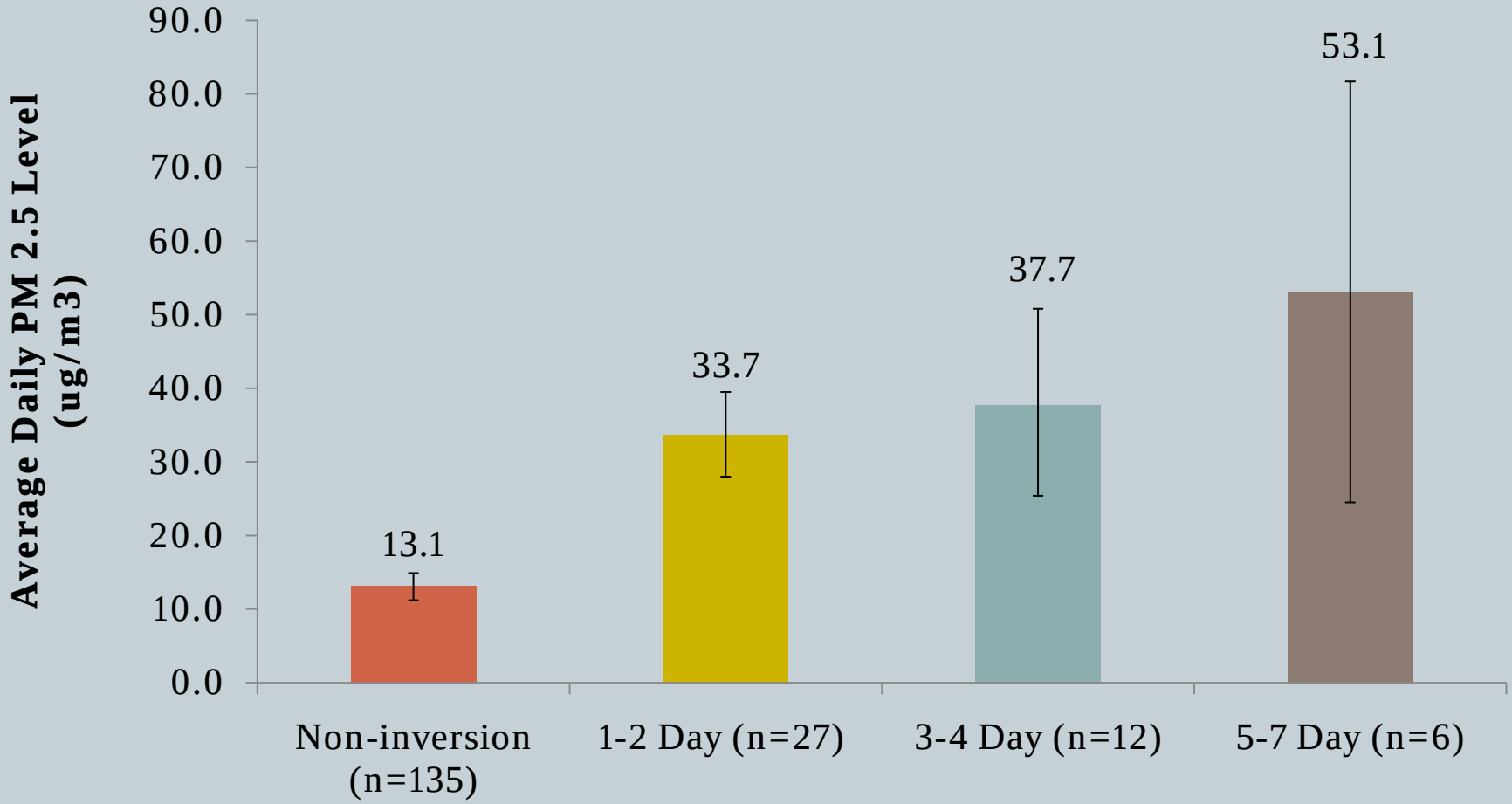
Distribution of PM 2.5 Levels on Non-inversion Days



Distribution of PM 2.5 Levels on Inversion Days



Average PM 2.5 Levels by Day of Inversion, Winters 2006-2007 and 2007-2008



Data Sources:
Identified inversion days: National Weather Service
Daily PM 2.5 Levels: http://www.epa.gov/airexplorer/ accessed March 2010.

Odds Ratio (OR)

- Definition: Ratio of the odds of an event (ED visit) occurring in exposed group compared to the odds of event occurring in non-exposed group

- Interpretation: OR higher than “1” indicates higher likelihood of event (can be used to approximate risk)

Odds of Asthma ED Visit on Inversion vs. Non-inversion Day

Exposure Variable	Odds Ratio (95% CI)*
No Inversion	Reference
Inversion: no lag	1.09 (0.92-1.28)
Inversion: 1 day lag	1.00 (0.85-1.17)
Inversion: 2 day lag	1.01 (0.84-1.22)
Inversion: 3 day lag	1.07 (0.90-1.27)

*Adjusted for temperature, NO2, SO2, and O3.

Odds of Asthma ED Visit Based on Number of Days of Continuous Inversion Exposure

Exposure Variable	Odds Ratio (95% CI)*
Non-inversion Day	Reference
1-2 day	1.03 (0.85-1.25)
3-4 day	1.09 (0.84-1.41)
5-7 day	**1.42 (1.02-1.96)**

* Adjusted for temperature, NO2, SO2, and O3.

AQI and Corresponding PM 2.5 Levels

AQI	PM 2.5 (micrograms/m^3)	Health Advisory
Good 0-50	0-15.4	None.
Moderate 51 to 100	15.5-35.4	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups 101 to 150	35.5-55.4	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy 151 to 200	55.5-150.4	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.

* Current 24-hour PM2.5 standard is 35 micrograms/m^3

Odds of Asthma ED Visit Based on Air Quality Index

AQI	No lag (95% CI)*	1 Day Lag (95% CI)*	2 Day Lag (95% CI)*	3 Day Lag (95% CI)*
Good (PM 0-15.4)	Reference	Reference	Reference	Reference
Moderate (PM 15.5-35.4)	1.02 (0.88-1.18)	0.98 (0.86-1.13)	1.04 (0.90-1.21)	0.90 (0.77-1.05)
Unhealthy for Sensitive Groups (PM 35.5-55.4)	1.08 (0.88-1.33)	0.96 (0.79-1.19)	0.87 (0.70-1.09)	0.88 (0.71-1.09)
Unhealthy (PM >55.4)	1.10 (0.80-1.50)	1.14 (0.85-1.54)	0.87 (0.61-1.23)	1.21 (0.92-1.59)

* Adjusted for temperature, NO2, SO2, and O3.

Other Findings

- Data suggestive of possible interaction between PM2.5 and inversions – insufficient data to be conclusive
- Similar findings when using any (rather than just primary) diagnosis of asthma as outcome

Conclusions

- On average, PM2.5 reaches levels that are unhealthy for sensitive groups during inversions lasting 3-4 days or longer
- No association between ED visits for asthma and PM2.5, including up to 3 days after exposure
- Odds of primary ED visit for asthma are 42% higher during days 5-7 of a prolonged inversion, compared to a non-inversion day

Limitations

- 24-hour averages of ambient PM2.5 used to measure exposure – individual exposure unknown
- Health effects outside of ED visits unknown
- Insufficient data to explore interactions between PM2.5 and inversions

Implications for Public Health

- Improved understanding of inversions and PM2.5
- People with asthma should take extra precautions during inversions, particularly prolonged ones
  - Regularly check ambient PM2.5 levels
  - Avoid or limit exposure to asthma triggers (e.g. exercise indoors)
  - Asthma medication use
  - Discuss personal steps to control asthma with physician

Available Air Quality Resources

- School recess guidance[1]
- Air quality websites[2]
- Red air day alerts
- Air quality tutorials[3]

1. *Available on the Utah Asthma Program website, at http://www.health.utah.gov/asthma/air%20quality/pm25.html.*
2. *Hourly air quality updates available at (http://www.airquality.utah.gov/)*
3. *Currently being developed by the Utah Asthma Program and the Department of Environmental Quality. Anticipated release in December 2010.*

Related studies

- Avery CL, Mills KT, Williams R, McGraw KA, Poole C, Smith RL et al. 2010. Estimating error in using residential outdoor $PM_{2.5}$ concentrations as proxies for personal exposures: a meta-analysis. Environ Health Perspect 118:673-678.
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Related Studies (cont.)

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Related Studies (cont.)

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- Levy D, Lumley T, Sheppard L, Kaufman J, Checkoway H. 2001. Referent selection in case-crossover analyses of acute health effects of air pollution. Epidemiology 12:186-192.
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- Maclure M, Mittleman MA. 2000. Should we use a case-crossover design? Annu Rev Public Health 21:193–221.

Related Studies (cont.)

- Mittleman MA. 2005. Optimal referent selection strategies in case-crossover studies: a settled issue. Epidemiology 16:715-716.
- Norris G, YoungPong SN, Koenig JQ, Larson TV, Sheppard L, Stout JW. 1999. An association between fine particles and emergency department visits for children in Seattle. Environ Health Perspect 107:489-493.
- Wallace J, Nair P, Kanaroglou P. 2010. Atmospheric remote sensing to detect effects of temperature inversions on sputum cell counts in airway diseases. Environmental Research 110:624-632.
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